



JANUARY, 1914

CIRCULAR No. 21

CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF THE COLLEGE OF AGRICULTURE

Department of Plant Pathology

THE YELLOW-LEAF DISEASE OF CHERRY AND PLUM IN NURSERY STOCK¹

VERN B. STEWART

Leaf blight, commonly known also as yellow leaf, or shot-hole, of plums and cherries, is one of the most important diseases attacking nursery stock. It was first reported in Europe in 1884 on *Prunus padus*, and has been common there on both sweet and sour cherries for the past twenty years. In America the disease has been reported on nearly all species of *Prunus*, both wild and cultivated. It occurs in all the nursery districts of the United States where cherry and plum stock is grown, and may be very destructive to nursery trees when weather conditions are favorable.

OCCURRENCE ON DIFFERENT HOSTS

Usually the disease occurs in abundance on the sweet cherry, *Prunus avium*, and on the wild chokecherry, *Prunus virginiana*. It is common on sour cherries, *Prunus cerasus*, *Prunus mahaleb*, and *Prunus pennsylvanica*, and on plums, *Prunus domestica*, *Prunus institia*, and *Prunus spinosa*. The leaves of *Prunus serotina* also are known to have been attacked.

In the nurseries of New York State the susceptibility of cherry and plum seedlings to the disease is of considerable importance. Mazzard cherry seedlings are very susceptible and often they are so badly defoliated that it is impossible to bud the trees. Mahaleb cherry stocks are attacked to some extent, but ordinarily the damage is less than on Mazzards. Myrobalan plum seedlings show a considerable degree of resistance and, at least in New York State, are seldom attacked.

The sweet-cherry varieties are more seriously affected than are the sour. Frequently, however, the disease is very destructive to all varieties of cherries and may cause a heavy loss of foliage. European plum varieties also may be defoliated completely by the disease during a season

¹ A report of work performed on the Stuart-Chase-Brown-Perkins industrial fellowship. The work has been made possible through the financial support and cooperation of the following nursery firms: C. W. Stuart & Co., Newark, New York; Chase Brothers Company, Rochester, New York; Brown Brothers, Rochester, New York; and Jackson & Perkins, Newark, New York.

of abundant rainfall (Fig. 1). Japanese plums are more resistant, and the disease is of little importance on these varieties (Fig. 2).



Figure 1



Figure 2

FIG. 1.— *European varieties of plums defoliated by the yellow-leaf disease*

FIG. 2.— *Japanese varieties of plums not affected by the disease*

discolored areas, usually not exceeding an eighth of an inch in diameter and more commonly about half that size. Later, after a period of seven to ten days, they become definite lesions, dark red or reddish brown in color. The infection may be confined to a small section of the leaf, but frequently the red spots, indicating the diseased areas, are thickly scattered over the entire leaf (Fig. 4). In the advanced stages a yellowing of the affected foliage may occur and the leaves may fall prematurely. The early loss of foliage affects the vigor of the trees; and the trees are poorly prepared to withstand the severe weather of the winter months, and begin growth the next spring with diminished vitality.

SYMPTOMS

The leaves, the fruit, and the fruit pedicels may be attacked, but generally the lesions are confined to the foliage and their occurrence on the fruit is rather uncommon. The disease is noticed first in the latter part of May or in early June. On certain hosts it becomes very noticeable because of the shot-hole appearance of the leaves. This condition is brought about by the dropping-out of the circular areas of affected tissue (Fig. 3). The shot-hole effect is commonest on plum varieties, in which the perforations may be so abundant that, owing to the dropping-out of the diseased areas, only remnants of the leaves are left. Infections on the Japanese plums are of a shot-hole nature, but it is believed that the larger percentage of the shot-hole effect on these varieties is caused by an insect; practically no defoliation occurs, as in the case of the European plum varieties.

On the leaves of cherries the diseased spots do not drop out so readily. They first appear on the upper side of the leaf as slightly



FIG. 3.— Shot-hole effect on plum leaves



FIG. 4.— Sweet-cherry leaves, showing the dark red spots and also the yellow discoloration

The same yellowing sometimes appears on plum leaves, but never so abundantly as on sweet-cherry foliage.

Particularly during periods of wet weather, small white velvety pustules may be observed on the lower sides of the leaves, opposite the discolored spots. Occasionally these pustules appear also in the center of the lesions on the upper side of the leaf.

CAUSE²

The disease is caused by the organism *Cylindrosporium padi*, which belongs to a low group of plants known as fungi. Many of these forms are parasites, living on other plants. This fungous organism obtains its food and nourishment by means of minute vegetative, rootlike strands, called mycelium, which penetrate the leaves of the host plant and cause considerable damage to the tissues invaded. The conditions of temperature and the amount of rainfall that favor the growth of the trees are favorable also for the development of the fungus.

LIFE HISTORY

With the active growth of the fungus in the leaf tissue, the mycelial threads form a closely packed mass near the surface of the leaf, resulting in the formation of a fruiting body (Fig. 5). From the tips of certain strands of mycelium in the fruiting body there are developed minute, sickle-shaped bodies, known as spores. The number of spores produced is usually very great, and the spores are pushed out in such large numbers on the under surface of the leaf that they become visible. This accounts for the occurrence of the white pustules previously described. The spores, being very minute, are easily carried to the leaves by wind and rain, and are thus disseminated over a considerable distance. Falling on a leaf, the spore germinates, if moisture is present, by sending out a slender germ tube (Fig. 6). This tube penetrates the tissue of the leaf, and with continued growth the germ tube develops a mycelium with many branches. These branches extend between the cells of the leaf, often penetrating them or sending sucker-like branches into them. The affected areas become disorganized, and in this way the mycelium derives its nourishment from the leaf. The attacked cells turn brown, and as the mycelium extends further into the tissue the discoloration increases resulting in the formation of the reddish-colored spots, as previously described. When a number of germ tubes attack the same leaf, a large part of it becomes affected. The living substance is destroyed and the leaf drops prematurely, being no longer able to function in the manufacture of food for the tree.

Throughout the summer the disease continues to spread with each period of wet weather, and as the new foliage develops it is in constant danger of infection. Often the trees may be defoliated completely by the latter part of August and the ground may be covered with diseased leaves. It is in these old, affected leaves that the fungus lives over winter. By the formation of a special fruiting body within the leaf tissue the

² A description by B. B. Higgins of the perfect stage of the *Cylindrosporium* on *Prunus avium* was published in Science (n. s. 37:637-638. 1913). Doctor Higgins named the fungus *Coccomyces hiemalis* Higgins.

organism is able to withstand the severe cold weather of the winter months. During periods of abundant rainfall in the following spring, when the trees are developing the first new leaves, these specialized fruiting bodies —

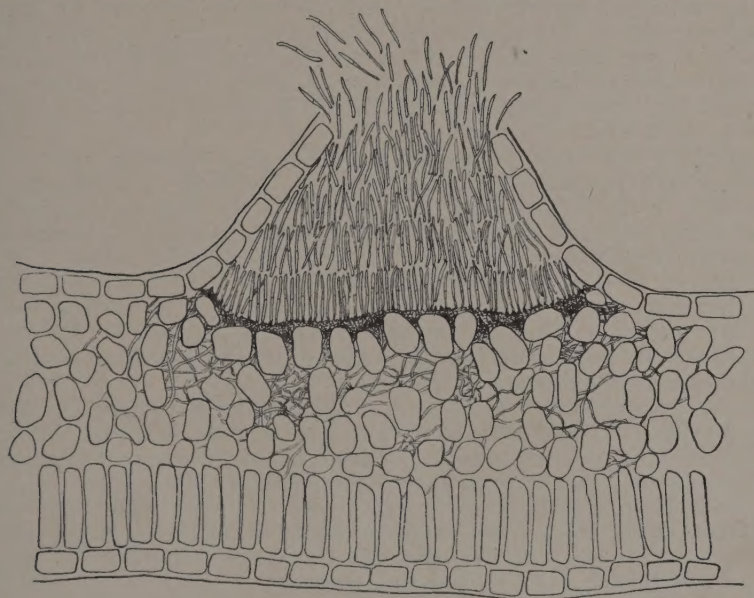


FIG. 5.—Cross section of cherry leaf, through a mature fruiting body of the fungus

known as perithecia — discharge large quantities of spores. Some of these spores are carried by the wind or by spattering drops of rain to the new foliage, where they produce the first infections of the year; and the characteristic diseased spots become apparent about seven to ten days later.

CONTROL

In the control of fungous diseases it becomes necessary to keep in mind the relation existing between the host and the fungus that causes the disease. In general, conditions of rainfall and temperature that influence the host plant affect also to some extent the activities of the fungus. Each rainy period of an ordinary summer season favors the growth of the trees, since sufficient moisture is supplied for their development. On the other hand, wet weather also affords necessary conditions for the fungus. Spores that are blown to other leaves are unable to germinate and produce infection unless moisture is present.

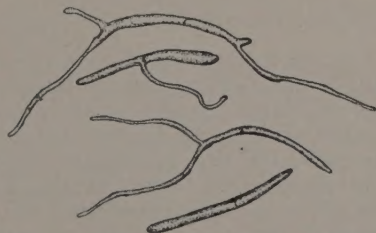


FIG. 6.—Spores of the *Cylindrosporium* fungus, some of which have germinated

The quantity of moisture required depends on the kind of fungus; but, in general, various fungi causing leaf diseases produce the greatest damage when damp, cloudy weather prevails for a period of twenty-four hours, or longer, after a rainfall. Drops of water falling on the leaves supply the spores with moisture for germination. The germ tube penetrates the leaf tissue within a period of a few hours and is soon able to obtain its nourishment from the affected tissue. To the naked eye, the first indication of the infections is the discolored areas that appear a week or so later.

After the spore has germinated and the germ tube has gained an entrance into the tissue, it is impossible to check the activities of the mycelium in the affected leaf. For control of the disease, therefore, it is necessary to check the fungus in its attacks before suitable conditions are afforded for the germination of the spores on healthy foliage.

If the old, diseased leaves that have remained on the ground throughout the winter are plowed under in spring before growth begins, a large source of early infection by the yellow-leaf fungus is eliminated. However, enough old leaves usually remain scattered about to enable the fungus to gain a foothold on the new leaves.

In order to prevent these attacks of the fungus and subsequent infection, the leaf surface must be covered with a fungicide, or a spray mixture which is highly poisonous to the fungus. When the spore germinates the germ tube comes in contact with the poison, is killed, and thus fails to produce an infection. Since the spores of the fungus are very minute — being about $1/500$ inch in length — the fungicide must be sprayed on the foliage in the finest mist possible in order that the leaves may be completely covered and thus protected from the attacks of the fungus. When the mixture is applied with insufficient force it accumulates in large drops on the leaf surface, and under such conditions spores lying between the drops of spray mixture may germinate and produce infection without being affected by the poison. As previously stated, after the germ tube has entered the leaf tissue and the mycelium is established, the spray mixture on the outside has no effect on the fungus. The fungicide does not penetrate the leaf and kill the fungous mycelium.

Time for spraying

In preventing the disease through spraying, it is necessary to make the applications at such intervals as will afford the greatest protection to the foliage throughout the growing season. Since the disease appears rather early in the season, it is advisable, for the nursery stock at least, to make the first application when the first-year cherry and plum buds are about eight to ten inches in height. Subsequent sprayings should be made in accordance with the weather conditions that exist. As a general practice, about five to seven applications throughout the summer, at intervals of two weeks, will suffice to keep the disease in check. A thorough spraying will protect the leaves for a long time, but it will not be of any value to the foliage developed subsequently. If the entire tree is to be protected, the new leaves must be sprayed shortly after they appear and as long as growth continues. During the active period of such stock as the first-year cherry and plum buds, it is often necessary

to make two or three applications at shorter intervals owing to the rapid development of new leaves. On the other hand, with prolonged periods of dry weather the trees do not grow so rapidly and the time interval between certain of the sprayings may be somewhat lengthened. The growth of two-years-old stock is also influenced by similar conditions, and sprayings should be made according to the weather that prevails.

It is to be remembered, however, that in order to insure protection to new foliage the spraying mixture must be applied *before* the rains and not afterwards. *The fungicides are not washed off by the rains*, but, on the other hand, when the foliage is thoroughly covered the mixture acts as a preventive against the attacks of the germinating spores during damp, cloudy weather. Spraying should never be deferred nor discontinued for fear that the mixture will be washed off; it dries rapidly, and when dry a sufficient amount remains to afford protection against the fungus even after continued heavy rainfall.

Spray mixtures

Bordeaux mixture or lime-sulfur solution may be used for the control of the disease. Bordeaux mixture may be made by the grower, or it may be bought on the market in the prepared form known as bordeaux paste or powder. Homemade bordeaux is preferable, since it remains in suspension somewhat longer than the market mixture and it also has better sticking qualities when applied to the foliage. Bordeaux, while effective, may cause burning of plum foliage. The formula most commonly used for making bordeaux mixture is: 5 pounds of stone lime, freshly slaked, and 5 pounds of copper sulfate (blue vitriol), to 50 gallons of water.

In recent years lime-sulfur solution has been substituted for bordeaux mixture in the control of various fungous diseases. This solution also may be made by the grower; but, unless ample facilities are at hand, it is preferable, for nurserymen at least, to use commercial lime-sulfur solution which can be bought in a concentrated form. Lime-sulfur solution is easier to handle than is bordeaux mixture, but care must be taken not to apply the solution at such a strength that it will cause burning of the foliage. For cherries and plums, the yellow-leaf disease may be controlled, without injury to the foliage, by using lime-sulfur solution at a strength of 1 gallon to 50 gallons of water.

The addition of granulated iron sulfate prevents the danger of burning and also increases the sticking qualities of the solution, especially if it is applied at a low pressure or with a gas spraying machine. When added to lime-sulfur the iron sulfate turns the solution black in color; and when sprayed on the foliage, after three or four hours exposure to the air, the spray material oxidizes to a reddish brown or a rust color. When iron sulfate is used the following formula is desirable for spraying cherries and plums: lime-sulfur solution (testing 32° Beaumé) 1 gallon, water 50 gallons, iron sulfate 1½ pound.

Spraying machines

Without question the greatest problem confronting nurserymen in the control of nursery diseases is a satisfactory means of applying the spray mixture. An apparatus is desirable which will apply the spray with

sufficient force and with the least inconvenience. For small hand sprayers, of which there are several types on the market, the common knapsack sprayer is the most desirable machine for efficiency. Considerable objection is raised by laborers to this machine because of its weight and the difficulty of carrying it.

Numerous compressed-air hand sprayers (Fig. 7) are in use, which are much lighter in weight than the knapsack sprayer; but none of these have



FIG. 7. — Compressed-air hand sprayer. Photograph by D. Gunn

been perfected to such a degree that they maintain a constant desired pressure. There is too great a decrease in pressure as the tank is being emptied. Compressed-air machines, however, are practicable if care is taken to pump them up frequently in order to maintain a good pressure.

The power sprayers used by some nurserymen have been of various kinds and as a whole are not entirely satisfactory. It has been difficult to construct a machine that could be transported over tall stock and at the same time be practicable for general use.

Without question a traction sprayer might be constructed so that it would be suitable for nursery work; but the greatest criticism of those that the writer has seen is that they have been built for use with one horse. It does not seem advisable to use a one-horse sprayer in large stock. With rows only three or three and one half feet apart, the shafts, in order to provide room for a horse of sufficient draft, must be set so far apart that they bruise and injure the trees. This is especially true when driving over rough and unlevel ground.

The construction of a two-horse machine is even more difficult, and those in use might be considerably improved. A sprayer of this type should be built to spray at least four rows of large stock, should be easy to transport, and should be equipped with a device that will furnish the necessary pressure for spraying. The power for spraying machines has usually been supplied by traction, gasoline engines, compressed-air tanks, or compressed carbonic acid gas. Since it is necessary for large nursery stock that a machine be built to order, the expense is rather high for the small grower. Under such conditions it is well to depend on hand sprayers for spraying large nursery trees, while a traction machine similar to that used for potato-spraying is very desirable for smaller stock.

In a large nursery where there are acres of large trees, it is preferable to have a machine that will permit the spraying to be done with con-

siderable rapidity and as economically as possible. The large two-horse machine appears to be the logical means of meeting these requirements.

For the past three years the writer has seen in operation a nursery sprayer (Figs. 8 and 9) that sprays four rows and clears all stock not exceeding six feet in height. The machine straddles two rows, and is operated with comparative ease with two horses. Two 50-gallon steel tanks are used for retainers of the spray mixture, and the power is furnished by compressed carbonic acid gas. The gas is obtained in steel drums and the spraying may be done with any pressure desired.



FIG. 8.—A two-horse gas-power sprayer for spraying all stock below six feet in height.
Photograph by D. Gunn

Usually, for general nursery spraying with two nozzles to each row, spraying four rows at a time, a constant pressure of 100 pounds is sufficient. One drum containing 50 pounds net of gas, costing \$2.50, will furnish power for spraying practically 500 gallons of spray mixture.

The most serious objection to the use of carbonic acid gas for power is the fact that it acts on lime-sulfur when this solution is used for spraying, and precipitates the sulfur. The precipitated-sulfur solution is less effective than the ordinary solution as an insecticide when used for San José scale or other scale insects. Therefore a gas machine should never be used for spraying lime-sulfur during the dormant season or before the leaves appear in the spring. Bordeaux mixture and arsenate of lead are not appreciably affected by the gas.

On the other hand, as a summer spray in the control of fungous diseases such as yellow leaf of cherry and plum, the value of lime-sulfur is not affected by the gas. The precipitated-sulfur solution is just as effective in keeping the fungus in check as when the solution is applied by means of other power. The sticking qualities of the solution are greatly increased by the addition of $1\frac{1}{2}$ pound of iron sulfate to the 1-50 lime-sulfur solution, previously discussed.

The machine illustrated in Figs: 8 and 9 has been in use for three seasons, and during the past summer a machine of a similar type,

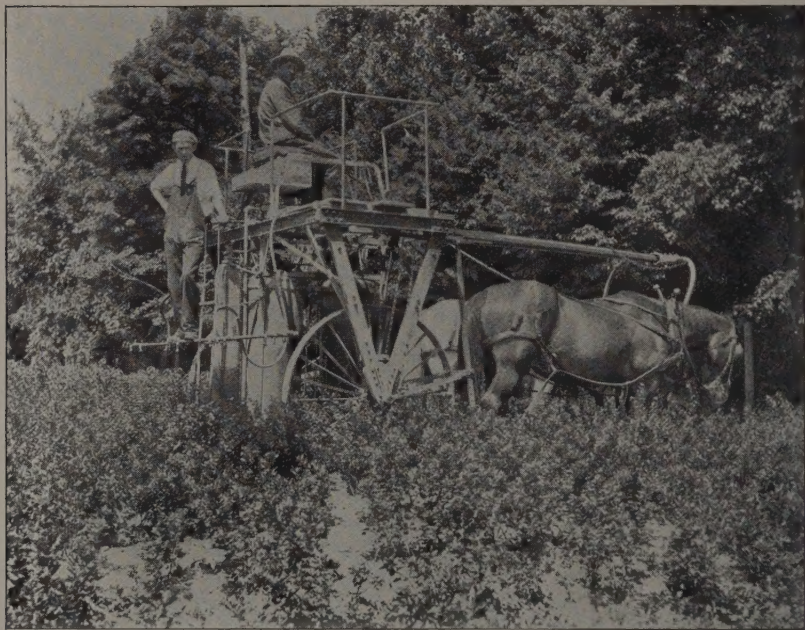


FIG. 9.— *The gas-power sprayer in operation. Photograph by D. Gunn*

but somewhat improved, was used in another large nursery. Where these machines are employed all the spraying has been under the direction of the writer, and in general the results have been satisfactory.

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